KIMBERLEY DIAMONDS: ESPECIALLY CLEAVAGE DIAMONDS.

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1. Local Characteristics.

The difference in character between the diamonds obtained from the different Kimberley mines has been noted often enough; albeit not always in terms that convey much idea of their meaning to most people who are not directly employed in the diamond trade. Indeed, it is doubtful if mere words are competent to express the subtle shades of difference, obvious enough to the expert, between, say, a crystal from Bultfontein and one from Wesselton.

One or two opinions from authorities of greater or less repute may be cited :

> "It is quite true that large parcels of diamonds from the various mines have distinctive characteristics, and it can be easily told from which mine a parcel of diamonds comes ; but it is very difficult to tell in which mine a single stone may have been found, though each mine has stones in a great measure peculiar to itself." (G. F. Williams, 'The Diamond Mines of South Africa,' p. 492, 1902.)
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> "The collective character of the stones found in each mine and in each part of a mine are distinctive, but single stones of every quality occur in all mines. Thus, though it may be impossible to state the particular mine in which a single stone was found, yet an experienced Kimberley diamond merchant would have no difficulty in naming the mine, or portion of a mine, from which a parcel of stones had come, provided that the parcel formed a fair sample of the yield of that particular deposit." (Bauer, 'Precious Stones,' English edition by Spencer, p. 212, 1904.)
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> "Most pipes were formed by a number of successive eruptions which gave rise to more or less well-defined columns of blue ground. Within any particular column of this nature the diamond content of the pipe rock is generally found to be remarkably uniform, but adjacent columns may differ markedly not only in their yield, but by producing diamonds of a distinctive character. So pronounced in some instances are the differences between the diamonds yielded by different columns

of blue ground that experts can with[out] difficulty determine not only from which mine, but from what portion of the mine, a particular parcel of stones has been derived." (P. Wagner, 'The Diamond Mines of Southern Africa,' p. 149, 1914.)

We propose first of all to amplify these three statements, and to illustrate them as far as it is possible to do so. Further references to the volumes in which they are contained will give the pages only, the titles will be understood.

Below are given representative assortments, in percentages, of parcels of diamonds from the Bultfontein, Wesselton, and Dutoitspan mines. Representative assortments for De Beers Mine, and for Kimberley Mine, separately, cannot well be given, since in the days when these two mines were in full swing the produce of the two was mixed together before being sorted. A specimen Pool assortment (as it is called) of De Beers and Kimberley diamonds mixed together is, however, given.

1. *Representative Assortment of Bultfontein and Wesselton Diamonds, in Percentages.*

	Bultfontein.	Wesselton.
Size of Parcel	70,208 cts.	59,600 cts.
A. *Close Goods.*	Per cent.	Per cent.
Blue Whites	·02	·30
Fine Whites	2·06	2·64
Whites	·55	1·16
First Capes	·31	1·01
Second Capes	·06	·30
Byes	·03	·03
Yellows	·03	—
First Fancies	1·20	—
Second Fancies	·60	—
B. *Irregulars.*		
Whites	2·85	3·21
Capes	·24	·71
Byes	·09	·02
Yellows	·01	—
C. *Spotted Stones.*		
Blue Whites	·02	·35
Whites	2·84	1·92
Capes	·68	·66
Byes	·11	—
Goods	—	·85
Good Capes	2·28	·19

	Bultfontein. Per cent.	Wesselton. Per cent.
Second Capes	2·74	·62
Darks	1·71	·57
Dark Capes	·24	—
Dark Byes	·04	—
Blacks	1·52	—
D. *Brown Stones.*		
Light Browns	—	1·74
Fancies	—	·75
Coated Stones	—	·20
E. *Flats.*		
Whites	1·27	2·75
Capes	·14	·43
Byes	·10	·05
Greys	3·43	4·72
Darks	1·05	1·13
F. *Cleavages.*		
Blue Whites	·14	·04
Fine Whites	2·67	3·06
Fine Capes	·19	·71
Byes	·03	—
Yellows	·01	—
Goods	2·15	74
Good Capes	·25	·32
Coloured	·70	·74
Greys	2·70	1·61
Darks	4·31	1·17
Blacks	4·74	—
Black Rejections	11·09	4·43
Light Browns	·22	·42
Browns	3·15	9·46
G. *Rejection Chips.*	—	3·65
H. *Rubbish.*	23·55	27·03
I. *Bort.*	18·00	20·31

2. *Representative Assortment of Pool and Dutoitspan Diamonds, in Percentages.*

	Pool.	Dutoitspan.
Size of parcel	30,760 cts.	30,900 cts.
AA. *Close Goods.*	Per cent.	Per cent.
Crystals	·07	·44
Capes	·07	·26

	Pool. Per cent.	Dutoitspan. Per cent.
Byes	·13	·41
Light Off-coloureds	·04	·23
Off-coloureds	·11	·94
Yellows	1·45	1.74
BB. *Spotted Stones.*		
Crystals	3·20	·54
Fancies		3·01
Byes	·27	·77
Off-coloureds	·56	·95
Yellows	1·98	1·79
CC. *Flats.*		
Whites	1·54	·07
Irregulars		2·90
Byes	·94	·95
Yellows	1·21	·68
Dark Yellows	·40	·07
DD. *Macles.*		
Ordinaries	·23	·03
Darks	·29	·12
Blacks	1·15	1·03
Rejections	1·23	1·14
Black Rejections	1·11	·46
EE. *Rejection Stones.*		
Ordinaries	·13	·83
Light Yellows	1·07	2·33
Yellows	·86	—
Darks	·76	2·23
Blacks	·44	1·04
FF. *Cleavages.*		
Whites	·62	1·05
Capes	·75	1·33
Byes	2·19	1·23
Yellows	1·84	1·93
Ordinaries	1·07	·77
Darks	·42	·77
Blacks	5·46	7·78
Rejections	·67	2·15
Black Rejections	10·97	8·83
Light Yellows	5·78	8·00
Yellows	3·42	—
Light Browns	·70	·48

	Pool. Per cent.	Dutoitspan. Per cent.
Browns	·28	·39
Dark Browns	4·81	7·00
GG. *Rejection Chips*	13·04	7·53
HH. *Rubbish*	19·80	15·45
II. *Bort*	8·93	10·33

Note.—Some caution must be exercised in making a first approximation to an interpretation of these percentages. It would not be fair, for example, to translate them at once into carats, and thence to argue that Wesselton produces more good white stones than Bultfontein does just because the numbers opposite "whites" are greater as a rule for the former mine. Actually the percentages of whites in the upper classes of Bultfontein are diminished because of the large number of Bultfontein white, or faintly tinted, diamonds which contain black spots—as may be seen in Class C, and especially in Class F, sub-classes greys to black rejections inclusive. Were these spotted stones (which are not numerously represented in the Wesselton yield) not in existence, Bultfontein would show the higher percentages of good whites.

Explanatory Notes on the Assortments.

A. *Close Goods* are diamonds of good colour and symmetry and free from all blemishes of spots or flaws. In this, as in all the other classes, the sub-classes stand in the order of merit; thus a white is esteemed more than a cape, a bye more than a yellow. The sub-classes are further sub-divided into lots arranged according to size.

B. *Irregulars* resemble close goods in all respects excepting that their symmetry is inferior.

C. *Spotted Stones* resemble close goods excepting that they contain internal white or black spots.

D. *Brown Stones* are diamonds of good symmetry and free from blemishes, excepting that they have a greater or less brown or smoky hue. In the case of the light brown stones the colour is pretty equally distributed throughout the mass, as it also is in the case of the fancies (see also under A, Bultfontein) which are mainly brown. On the other hand, the smoke-brown tint of the coated stones is often confined to the surfaces, and is due to a thin deposit of opaque material, probably caused by corrosion. Coated stones are what is called "speculative" stones, since they may be good or bad inside. Pretty often they are very good indeed. They always command a good price. Bultfontein fancies differ from Wesselton fancies.

E. *Flats* differ from close goods in the matter of symmetry, namely, that their thickness is small in comparison with their length and breadth.

Some of these are no thicker than a visiting card. Macles (for the definition of which see any standard work on crystallography) go into this class. Mineralogists and crystallographers, outside the diamond trade, commonly give the name "spinel twins" to macles. The term is not without objection, because it is calculated to make the multitude think that a macled diamond is really a spinel. It is better to confine the name "macle," in accordance with Kimberley practice, to stones in which the crystallisation has taken place right- and left-handed from a common basal plane without interpenetration from either, and to use "twin" for interpenetrating crystals.

F. *Cleavages* will be dealt with at some length later on. Here it is enough to say that the first five sub-classes—from blue whites to yellows, that is—are of good quality, colour, and shape; whereas the remaining sub-classes, from goods to black rejections, are inferior in all ways, and in the majority of individuals are spotted. Brown cleavages bear much the same relation to brown stones that the first five sub-classes of cleavage bear to close goods.

G. and H. *Rejection Chips and Rubbish* are made up entirely of diamonds so defective in the requirements of a passable stone that no place can be found for them in any of the higher classes lest they spoil the look of the whole parcel. They comprise diamonds of all sorts other than true bort—the ragtag and bobtail of each. A good quantity of this stuff goes into cheap jewellery; much of it is used for industrial purposes, *i. e.* for graving tools, glaziers' diamonds, and watch pivots. Bultfontein does not produce so many small diamonds, averaging, say, a dozen to the carat, as Wesselton does, which is one good reason why it has not a class of rejection chips of its own. Such rejection chips as it has go into the rubbish.

I. *Bort* is mostly converted into powder for grinding and polishing purposes. There is a large demand for the best pieces for use in rock drills. Notwithstanding that bort only averages 5*s*. or 6*s*. a carat, really good "shot bort" will fetch as much as £4 or £5. Some of the distinctive types of bort will be described presently. Diamonds not good enough even for the rubbish go into this class.

AA. *Close Goods.* See the remarks under A.

BB. *Spotted Stones.* See C. In sorting Pool or Dutoitspan goods for the market, fancies find their best home in this class.

CC. *Flats*, here, really contain a few macles; but most Pool and Dutoitspan macles do not harmonise as well with the flats as Wesselton and Bultfontein macles do, and so we have a separate class of—

DD. *Macles* which are characteristic, in colour and shape, of the former mines. They tend to a greenish-grey, are often much spotted, and have, with few exceptions, rounded edges sloping outwards (not inwards like spinel twins) to the common basal plane.

EE. *Rejection Stones* are inferior spotted stones not good enough for BB.

FF. *Cleavages.* See F.

GG, HH, II. *Rejection Chips, Rubbish, and Bort.* The remarks under G, H, I, apply in general in these cases also.

It is to be noted that these assortments are on a strictly commercial basis. They have the market in view, and the market only, therefore they cannot fully answer all the questions that science would put; but they give useful testimony as to the outstanding points of difference between the parcels of diamonds from various sources. Roughly speaking, one system of sorting does for both Wesselton and Bultfontein, and another system for both Pool and Dutoitspan. All the same, that is not to say that for any assigned class, common to the two mines, the diamonds belonging to that class from one mine are the counterparts of those from the other. The Bultfontein cape stone, *e.g.* is not quite the same as the Wesselton cape. A Dutoitspan yellow has a somewhat different glow from a De Beers yellow. Bultfontein browns are sorted in with the fancies. Both they and the Wesselton browns are less full in colour than Pool browns; indeed they are smoky rather than brown. Still more diverse are Wesselton whites and Dutoitspan whites. Again, the Bultfontein yield sorts into more classes than does the Wesselton yield, there being small classes of coloured diamonds in the former which are not represented at all in the latter, which is curious, seeing that a Bultfontein parcel has quite as white a tone as a Wesselton one. As it happens, many of the yellow diamonds, and particularly the larger ones, found in Bultfontein are what is called Dutoitspan yellows; that is, they have the Dutoitspan and not Bultfontein characteristics; and this fact, coupled with the occasional find of a diamond with Bultfontein characteristics at Dutoitspan, is thought to indicate some deep underground connection between the two mines (Hatch & Corstorphine, Geology of South Africa,' second edition, p. 276, 1909; Wagner, p. 151). The superior quality of the Dutoitspan yield over that of the Pool is well shown by the greater percentage of Dutoitspan diamonds in the upper classes. An excellent brief general account of the characteristics of the diamonds from the several mines will be found in Hatch & Corstorphine, p. 275, made up from notes supplied by A. Brink.

As to the denominations, it should be explained that "black" is not black in the sense in which lady novelists use the term when they rhapsodise over their heroine's priceless black diamonds. It simply means diamonds in which black spots are abundant. In Kimberley colloquial speech a black diamond is generally bort when it is not coal.

2. COMPARATIVE STATISTICS OF LARGE DIAMONDS.

One of the most noticeable points of difference between the diamonds produced from this or that mine in the Kimberley group is in the matter of size. Taking all diamonds of 10 carats each, or greater, we have the following comparison:

Year.	Mine.	Total production in thousands of carats.	Average size of diamonds of, or exceeding, 10 carats.	Ratio of total weight of diamonds exceeding 10 carats to total production.	Number of diamonds of, or exceeding, 10 carats each in every 100,000 carats produced.
			Carats.	Per cent.	
1898	De Beers . .	1897	18·2	12·25	674
1898	Kimberley . .	652	17·0	11·65	684
1912	Wesselton . .	560	15·5	2·32	140
1912	Bultfontein .	893	14·9	·97	65
1912	Dutoitspan .	504	20·0	17·02	850

Thus diamonds exceeding 10 carats each in weight are relatively infrequent at Bultfontein, and average small; whereas upwards of one-sixth of the Dutoitspan yield consisis of stones averaging 20 carats each.

This is remarkable, seeing that these two mines are so close together that they could even be worked (though perhaps not very profitably) from the same main shaft, and possibly have, as we have just said, some underground connection. Comparing one mine with another, the rule is essentially: The greater the average size of diamonds exceeding 10 carats each, the greater the ratio of their total weight to the total production, and the greater their number in every 100,000 carats produced. Kimberley Mine deviates slightly from the rule in the second particular.

3. Less Obvious Differences.

Besides all this there are the subtle differences, previously alluded to, between the diamonds from different mines, which, though they (the diamonds) may be called by the same name, have yet an undoubted dissimilarity one from the other made up of almost indefinable distinctions of lustre, brilliancy, crystallisation, appearance, texture, and general tone. Among other things there is the characteristic rippled surface of a Dutoitspan diamond as compared with the smooth surface, often with numerous triangular indentations, of a Wesselton diamond, and as compared with another from Bultfontein. The passages cited at the beginning—which are not really independent statements—really understate the case. A person not in daily contact with Kimberley diamonds would naturally not be able to recognise these differences, but an expert can do so more readily than might be supposed. Single stones of every quality, it may be added, do *not* occur in all mines.

Slight differences have been suspected, and may indeed exist, between the lustre of diamonds won from different depths in the same mine. The evidence, however, is hardly stronger than that of mental impression based upon memory. While the expert may honestly think that the diamonds now mined are brighter, or less bright, than they used to be, there is just the possibility that his eyes may have deteriorated or his memory been at fault. Moreover, it is not practicable in the process of mining to keep the diamonds belonging to different columns of the same pipe entirely separate, and also the columns may not be of the same relative cross-section throughout, so that at one level in the mine the output may consist of a greater proportion of diamonds from one column than it does at another level.

4. OCTAHEDRA.

The perfect octahedron is a rarity. Perhaps a few dozen have been found in the mines of the Kimberley group in forty years, and one at any rate of these was found entirely enclosed in another diamond—which suggests the possibility that any octahedron of a perfect shape, with sharp edges that is, may have spent its existence, until it reached the surface, inside another diamond. Bauer's statement that "the edges and corners of the crystals [of Kimberley diamonds] are always perfectly sharp, not even the faintest trace of rounding can be detected," is not even approximately true. Yellow octahedra are rare. The common bright yellow diamond is nearly always rounded.

5. COLOURS.

Orange-coloured diamonds are only found, as a rule, in the Wesselton Mine. This is curious, too, for *a priori* one would have expected to find them in mines where yellow diamonds abound, *i. e.* in De Beers, Kimberley or Dutoitspan. They are practically always in misshapen fragments, like their associated minerals garnet and zircon, and doubtless owe their condition to much the same causes as wore or broke down those. They are nearly always small, not often exceeding 1 carat, and not more than half a dozen or so of them are found in a month. They keep their original colour pretty well, as a rule, after cutting. In the collection of brilliants exhibited in the Kimberley office of the De Beers Company is a beautiful rich orange-coloured diamond weighing 2 carats, cut from one of the largest of such fragments yet found. G. H. Smith's assertion ('Gem Stones,' p. 151, 1912), that the "Wesselton Mine yields a large proportion of flawless octahedra, but above all a large number of beautiful deep-orange diamonds" is perhaps approximately true as to the first half, but not reasonably true as to the second.

Pale lilac fragments are met with at rare intervals, and one reddish lilac diamond has been found and preserved, which, in shape, is like a long, flat bean, and yet has natural, though possibly secondary, faces.

Now and then stones with a greenish cast are found, chiefly in De Beers and Kimberley. They range in colour from a faint chrysolite green to sage.

The lighter greens are nearly always found among rounded octahedra, and the colour appears to be concentrated in the crystal corners, and hence almost entirely disappears in the cutting, as we are told and should half expect. The sage greens are disappointing as brilliants; though they are uncommon they are not prized, for they have no life and little beauty. Steel blue and sapphire blue diamonds, like those from the Premier Mine in the Transvaal, have not been found near Kimberley.

Brown diamonds ranging in colour from smoke-brown to chocolate are found, those of the latter colour rare and precious as brilliants when they possess "fire." Beautiful pale brown and autumn brown stones, of large size up to a hundred carats but of flat and irregular habit, used to be found in the Pool. Inexperienced diggers have been known to throw them away, mistaking them for "Dutch bort" (zircon). One fine piece, worth upwards of £200, was ascertained to have been thrown away by one *débris* washer after another before it finally reached the market.. Such stones cut very well. Their early history in the pipes must have differed much from that of the majority of diamonds.

After all, if the truth must be told, the common yellow diamond is by far the most beautiful of all, and it would be esteemed the most if it were less common. And it has this advantage, which a good many white stones have not—that it is full of fire by day or by night. The great Tiffany lemon yellow brilliant is a proof of this affirmation. Judging by descriptions and by glass copies, it is a Dutoitspan diamond.*

Stones showing slight colour effects under the polariscope are not at all uncommon, but they are conceivably not so common as is sometimes asserted. The statement that nearly all Kimberley diamonds show signs of great internal strain is no more than assumption based on casual examination of a comparatively few specimens, and is scarcely more likely to be generally true than the old idea, still believed by many—that all diamonds phosphoresce after exposure to sunlight. How many South African diamonds ever go near a polariscope?† (But see Sir William Crookes's Kimberley lecture on Diamonds, 1905.)

6. Bort.

Perhaps the bort class is the most interesting of all. "Bort" as a commercial term includes inferior representatives of all the other classes besides true bort. True bort consists of crystalline aggregates of tiny particles arranged anyhow in rounded lumps. The prevailing colour is grey, and in the mass it is opaque. But very elegant cubes and spheres of this material, ranging in colour from fawn to dove, occur which are quite translucent. Typical Wesselton bort is a sort of semi-translucent substance, black by reflected light, with a lustre remotely reminiscent of tourmaline. We meet with occasional fragments of black bort, an amorphous material perhaps more nearly allied to carbonado than to true diamond. This occurs in greater abundance in the Transvaal workings than at Kimberley, and pieces have been found on the Vaal River and at Jagersfontein. It occurs in the form of irregular lumps, and is not favourably regarded as diamond at all in the market. A beautiful and unique specimen of this class, in shape generally rounded but with the corners sticking out, much like a De Beers' yellow stone in habit, is in my keeping. D. P. McDonald has described a piece of this kind of bort in "Notes on a Form of Black Diamond from the Premier Mine" ('Trans. Geol. Soc. S. A.,' 1913). This material is now known as framesite.

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* The Tiffany diamond is commonly said to have been found in the Kimberley mine in 1878. The diamond fields newspapers of that year, however, do not report such a find.

† Crystals and crystallisation have always provoked random theories. Note, *e.g.* the old and utterly unobservant idea, endorsed by no less a philosophic autocrat than the 'Encyclopædia Britannica' that "hoar frost is nothing but dew turned into ice by the coldness of the air" (3rd edition, 1797).

Bauer's statement that 90 per cent. of South African bort comes from the Kimberley Mine was wrong when he wrote it, and is still more wide of the mark now.

7. STEWARTITE.

The most interesting and most important individual of all the very diverse bort family is the substance for which the name "stewartite" has been adopted, and which claims a section for itself. This was discovered by J. Stewart. It is of a steel-grey colour, with a dull steely sheen, and is more fibrous in texture than the types of bort mentioned above. In hardness it equals the diamond, but its specific gravity is rather less.* It is a good conductor of electricity, like other borts. Its most remarkable property, though, is that it is magnetic and polar, and thus it has an important bearing on Crookes's theory that diamond has separated out from molten iron. Being magnetic, it must contain iron; and because it contains iron and carbon in association and is polar, we might almost call it a steel bort. Hitherto iron had only been found in infinitesimal quantities in the ash left after burning a diamond.

The properties of stewartite recall those of the fabulous, or alchemical, adamant of the Middle Ages, when a confusion of ideas (for it is difficult to conceive that there could have been an adequate knowledge of the facts) seems to have evolved an imaginary substance combining the properties of diamond and lodestone. Chaucer seems to have distinguished between diamonds and lodestones, though possibly not by intention, using the spelling "adamauntes" for the latter and "ademauntz" for the former. Thus (Morris's ed., 1886):

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* S.G. = 3·45.

> "Ryght as betwix adamauntes twoo
> of evene wyght, a pece of iren isette
> Ne hath no myght to meve to no fro."
> ('The Parlement of Briddes.')

And so in 'The Romaunt of the Rose.'
Whereas

> "The dores were alle ademauntz eterne."
> ('The Knightes Tale.')

Gower uses "adamaunt" and "adamant" in our sense as "diamond." On the contrary, Shakspere uses the same word ('M. N. D.,' II, 1) in the sense of lodestone, although his "hard-hearted adamant" has a flavour of the diamond about it.

The 'Oxford English Dictionary' has an interesting article on the word "adamant," and a number of quotations from English authors down to 1750, which prove how little was known at first hand, or by experiment, of the properties of either lodestone or diamond. By many the adamant was thought to be a sort of natural opponent of the lodestone, counteracting the attraction of the latter for iron. Others regarded the adamant and lodestone as identical, and thought that the diamond was the natural opponent of both.

There is a good specimen of stewartite in the McGregor Memorial Museum at Kimberley. The substance described by Wagner (p. 143) is, of course, not stewartite at all, but black bort, the same as, or allied to, the black bort mentioned in the previous section.

8. Variation of Quality and Increase in the Output of Cleavages, with Depth of Working.

The question is often raised whether the average quality of the diamonds found in the different mines deteriorates with working depth. It is a difficult question to answer definitely, because the methods of winning the diamonds have improved with experience; so that small diamonds which might have been lost twenty years ago are now saved, and hence that the average value must decrease. In other words, the proportion of good stones to bad must decrease even if the larger ones are as good as ever they were. In the table following are given for each year 1902–16 the relative proportions for Bultfontein of—

(1) *Stones—i. e.* Close Goods, Irregulars, Spotted Stones, and Flats;
(2) *Cleavages;*
(3) *Rubbish and Bort;*

the mean working depth from which the diamonds were won increasing in that time from about 300 feet to 850 feet. The first column gives the years, the second the number of carats in thousands (M) sorted for sale, while the others show percentages of each class.

Table Showing the Percentages of each Class of Diamonds from the Bultfontein Mine.

Year.	Carats sorted. M.	Stones. Per cent.	Cleavages. Per cent.	Rubbish and bort. Per cent.
1902–4	265	29·54	29·03	41·43
1905	291	30·84	34·87	34·29
1906	533	28·87	36·27	34·85
1907	506	26·61	35·73	37·66
1908	398	26·56	33·48	39·96
1909	670	25·05	32·01	42·94
1910	678	23·89	34·08	42·04
1911	778	23·87	35·70	40·43
1912	855	23·12	36·63	40·25
1913	787	22·25	36·30	41·45
1914–16	992	23·19	32·64	44·16

The first line is not perhaps fairly comparable with the others, since it represents the first years in which systematic work was begun by the De Beers Company, and no doubt some clearing up from previous irregular work by various small companies had to be done. But from 1905 onwards there seems to have been a pretty clear increase, on the whole, in the rubbish and bort of about 10 per cent. At the same time the cleavages have been very little affected, while the ratio of stones has decreased from say 30 to 23 per cent. If we assume that the increase of rubbish and bort is due to improved mining methods, and reduce the ratio of rubbish and bort accordingly, this would indicate that the quantity of stones found has not decreased much, if at all, and may indeed have increased somewhat.

With this there does seem to have been an increase in the actual yield of brown diamonds as compared with the rest. The following are the separate percentages of brown and other cleavages:

Year.	Brown cleavages. Per cent.	Other cleavages. Per cent.
1902–4	3·92	25·11
1905	2·96	31·91
1906	3·45	32·80
1907	3·85	31·88
1908	3·91	29·57
1909	3·52	28·49
1910	3·84	30·22
1911	3·88	31·82
1912	4·15	32·48
1913	4·28	32·02
1914–16	4·38	28·26

Whether any of this result is due to psychological reasons is hard to say. Diamond coloration merges from one class to another not by steps but imperceptibly. And it might therefore be plausibly urged that some cleavages which formerly were not brown enough to be called brown are now so called; or that it is likely that improving markets have to some extent justified the promotion of individuals from the rubbish into the brown cleavages. Neither alternative has any trustworthy evidence in its favour, and my own impression is that the increase in the brown cleavages is real, the small deviations from a uniform increase showing no definite relationship to the deviations of rubbish and bort.

The next table gives similar information for Wesselton for the years from 1898 to 1916—namely, the relative proportions of—

(1) *Stones—i. e.* Close Goods, Irregulars, Spotted Stones, Browns, and Flats;

(2) *Cleavages;*

(3) *Rejection Chips, Rubbish, and Bort;*

the mean working depth from which the diamonds were won increasing in that time from 125 feet to 800 feet.

Table Showing the Percentages of each Class of Diamonds from the Wesselton Mine.

Year.	Carats sorted.	Stones.	Cleavages.	Rejection chips, rubbish and bort.
	M.	Per cent.	Per cent.	Per cent.
1898	378	31·72	17·06	51·22
1899	447	29·53	15·47	55·00
1900	308	28·14	15·51	56·35
1901	484	28·08	16·33	55·59
1902	541	26·65	17·76	55·59
1903	580	25·97	17·86	56·18
1904	612	23·86	19·20	56·93
1905	567	24·98	19·39	55·63
1906	590	24·41	20·56	55·03
1907	472	26·81	23·67	49·52
1908	397	25·95	23·86	50·19
1909	618	25·56	24·72	49·72
1910	525	25·81	25·61	48·57
1911	409	24·39	23·43	52·18
1912	522	24·17	24·87	50·96
1913	602	23·05	25·20	51·75
1914–16	634	23·38	23·05	53·57

Here we find, so far as the statistics can show it, a decrease in the percentage of stones of about 7 per cent. (about the same as that of Bultfontein in a little shorter time); an increase of cleavage of about the same amount; and a remarkable fluctuation in the percentages of rejection chips, rubbish, and bort, the curve of these showing, on the whole, a maximum in 1904, followed by a minimum in 1910, and after that a rise to the present time.

Curiously enough, the brown stones show a uniform decrease with time, whereas the brown cleavages show a definite increase, thus:

Year.	Brown stones. Per cent.	Brown cleavages. Per cent.
1898	2·82	5·17
1899	3·10	6·35
1900	2·97	6.44
1901	3·55	6·20
1902	3·33	7·15
1903	3·14	7·22
1904	2·62	8·19
1905	2·49	7·63
1906	2·37	8·21
1907	2·65	9·65
1908	2·29	9·61
1909	2·28	10·70
1910	2·17	10·84
1911	1·97	9·64
1912	1·89	10·13
1913	1·90	10·57
1914–16	2·12	10·13

This is an extraordinary result, and requires more material for its full elucidation than has yet been accumulated. It would appear from the face value of the relative numbers that brown stones have shown a greater disposition to break up in the deeper levels of the Wesselton Mine than in the upper ones. Also that brown diamonds (stones and cleavages together) have increased by about 3 per cent. in eighteen years, the fluctuations showing some, if small, agreement with those of rejection chips, rubbish, and bort.

Comparing stones other than brown with cleavages other than brown, we have—

Year.	Stones not brown. Per cent.	Cleavages not brown. Per cent.
1898	28·89	11·89
1899	26·43	9·12
1900	25·17	9·07

Year.	Stones not brown. Per cent.	Cleavages not brown. Per cent.
1901	24·53	10·13
1902	23·32	10·61
1903	22·83	10·64
1904	21·24	11·01
1905	22·49	11·76
1906	22·04	12·35
1907	24·16	14·02
1908	23·66	14·25
1909	23·28	14·02
1910	23·64	14·77
1911	22·42	13·79
1912	22·28	14·74
1913	21·15	14·63
1914–16	21·26	12·92

Here we see that there has, apparently, also been a disposition for these whiter diamonds to break up more freely at the greater depths, although not to the same extent as in the case of the brown diamonds. For whereas in the five years 1899–1903 67 per cent. of all brown diamonds was brown cleavage, in the five years 1909-13 the cleavages had increased to 84 per cent., an increase of 17 per cent., the corresponding percentages for diamonds other than brown being 29 and 39, an increase of 10 per cent. Moreover, in absolute numbers, the chances preponderate that a brown diamond will be a cleavage, whereas the odds are quite the other way when the diamond is not brown. There is pretty well as much brown cleavage as there is cleavage not brown; the stones other than brown outnumber the brown stones by ten to one. Bauer, in one of his characteristic inaccuracies, has stated that in the case of Cape diamonds "it is a remarkable fact that these cleavage fragments are nearly always white—that is, colourless, or, at least, very faintly coloured; fragments of a dark colour, or of a decided yellow, are extremely rare, so that we must conclude that such stones offered greater resistance to fracture than did the colourless diamonds" (p. 209). The above statistics show just the opposite—that it is the colourless diamonds rather which resist fracture, as compared with brown, at any rate, although, as we shall see when we come to speak of Pool and Dutoitspan diamonds, yellow diamonds are perhaps more resistant than white. Apart from any question as to the influence of colour upon the cohesion of a diamond, we should naturally expect cleavages to appear somewhat lighter in colour than stones, for the same reason that many cut diamonds appear lighter in tint than they did when in the rough. A good deal of the colour in some rough stones seems to be concentrated in the crystal corners from which it is reflected inwards, so that if the stones were to be broken the fragments would assume a lighter tint. We have also to remember such a fact as that the deepest coloured glass appears lighter in colour when broken into small enough fragments, and quite white when reduced to powder. Diamonds may look lighter in colour because they are broken; they do not break because they are lighter.

9. Cleavages.

One point to be noted concerning what are called cleavages is that some of them are not broken diamonds at all. Wodiska's statement ('A Book of Precious Stones,' 1910) that "cleavage" means broken stones is too uncompromising. "Cleavage" is a trade term which indicates not only diamonds now broken, but those which will have to be broken before being finally cut into gems—potential cleavage, in fact. All very misshapen stones and interpenetrating crystals, besides broken pieces, are cleavages in the eyes of a Kimberley diamond merchant, just as all flesh is grass, and so are feathers too, in the eyes of the philosopher. Bultfontein produces numbers of these interpenetrating crystals, or cross-grained stones, as they are called. Some of them take strange forms: a fine white one in my collection is like two mace-heads, with sharp, projecting points, joined together. The term "cleavage" does not apply, however (as Bauer says it does), to crystals containing spots which would have to be cleaved before being cut. A crystal containing spots is a "spotted stone," and is denominated dark, black, or black rejection, according to its quality. Some of these so-called cleavages have evidently crystallised in a tight corner, judging by their distorted outlines and by the fact that sporadic specimens appear to have surfaces of attachment like quartz. Others appear to have been broken at an early stage, and to have undergone further growth or suffered resorption. It is truly remarkable how many of these so-called cleavages seem to have been naturally refaced either with a nascent or with a pocky surface. The triangular indentations indicating growth—so common on the faces of Wesselton octahedra—do not, nevertheless, seem to occur on these naturally renovated cleavage faces; instead, striations like those on yellow diamonds are the rule.

10. Broken Diamonds.

The origin of the numerous broken fragments of diamond is somewhat of a mystery. G. F. Williams (p. 492) remarks that—"Some observers claim that the broken diamonds which are extracted are broken during the process of winning them. It is admitted that diamonds may be broken in the process of mining and the subsequent operations of winning, but these cases are exceptional. Fragments of diamonds are very frequently found embedded in the blue ground, and there is no doubt in the mind of anyone who has had practical experience in finding these fragments that they were not crystallised where they are found." On the substructure of this evidence Wagner (p. 164) and Bauer (p. 195) assign the origin of Kimberley diamonds to a deep-seated plutonic rock, claiming that the broken fragments owe their condition to violent eruptive outbursts which shattered country rock and blue ground alike.* The latter, however, stultifies his argument to a certain extent in his very next paragraph, where he states that the minerals and rock fragments in the blue ground show no signs of wear and tear. It is hard to see how the diamonds could have suffered so much damage and their kimberlite surroundings none at all. As a matter of fact, better authorities tell us that the rock fragments in the pipes do show a great deal of wear and tear. (See A. L. du Toit, "Geological Survey of the Eastern Portion of Griqualand West," in the Eleventh Annual Report of the Cape Geological Commission, 1906.) Du Toit, it may be noted, provisionally accepts the theory that the shattering of the kimberlite accounts for the fracturing of diamonds, but observed that garnets have not suffered to the same extent (p. 151).

11. SPONTANEOUS BREAKING.

A more attractive theory, and one repeatedly quoted from one to the other by writers on the diamond, is that certain classes of diamonds frequently tend to break of themselves. G. F. Williams (p. 500) is responsible for the opinion that "light brown, smoky diamonds often crack on exposure to the dry air, but they will remain intact if kept in a moist place. The cracking is, therefore, more probably the result of heat or drying than of tension or inward [? interior] pressure. It is possible, however, that the great heat to which the diamond is exposed when brought to the surface may expand contained gases sufficiently to crack the stone." Crookes, on the other hand (Kimberley Lecture), seems to attribute the fractures to sudden lowering of pressure in the space surrounding the diamonds, and speaks of consequent explosions. G. H. Smith (p. 131), following Crookes, says that "so great is the strain that many a fine diamond has burst to fragments on being removed from the ground in which it has lain."

Unfortunately, the evidence for this particular theory, as a complete theory, is not strong nor very extensive. What, at first sight, might look like a consensus of scientific opinion is, in reality, gossip handed on from one to the other by nearly all, and is by no means the outcome of independent research. Personally, I have met plenty of people who have *heard* of the bursting of smoky diamonds without ever having witnessed such a disaster with their own eyes, and the story of the custom of sending them to England inside potatoes is almost a chestnut. Certainly the De Beers Company never pack any of their millions of diamonds in potatoes. A possible case of spontaneous breakage is known in the De Beers' sorting-office, and another, in which a crack was found in a diamond where no crack was observed—and the chances are, did not exist—before. Besides this, there are many brown and other fragments which do possess very fresh-looking cleavage faces, and so might have done as the frog did in the fable.

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* *Cf.* also L. J. Spencer in 'The World's Minerals,' p. 46, 1911.

And then there is the deduction from the statistics, previously remarked upon, that the proportion of brown cleavages to brown stones is unduly high. All this hints at the possibility of some measure of early or late spontaneous disintegration, but no more. Moreover, a great many broken diamonds are not brown or smoky at all. Anyway, diamonds do not *explode* of themselves under meteorological conditions. It is said that certain philosophers, acting under the orders of the Grand Duke of Tuscany, once caused a diamond to explode by exposing it to the sun's rays in the focus of a powerful lens two-thirds of a Florentine ell in diameter; but in this case, since the diamond was of a good size—nearly ten carats in weight—the result might have been caused by unequal heating rather than by the terrific heat alone.

If heat will not cause a diamond to shiver (!) according to Crookes, and moisture will prevent such a catastrophe according to Williams,* it is not easy to understand what any "cunning dealer," wishing to buy but taking no unnecessary risks, has to gain by encouraging sellers to handle their goods freely or carry them in their warm pockets, which is what we are told the cunning dealers do; and cunning indeed they must be if they can so contrive, and foolish the seller who could be so circumvented. It is to be suspected that much of the myth that has collected round the nucleus of an occasional accident to a smoky diamond is derived from the old story of Albertus Magnus, that a diamond immersed in the fresh, warm blood of a goat (especially if the animal had previously browsed on parsley or drunk wine) would burst. Pliny, it will be remembered, had a similar idea—namely, that the blood of a billy-goat had power to lessen the molecular cohesion of the adamas stone, which stone seems to have been diamond but may have been something else: "The blood, however, must be no otherwise than fresh and warm; the stone, too, must be well steeped in it, and then subjected to repeated blows; and even then it is apt to break both anvils and hammers of iron if they be not of the finest temper" (xxxvii, 15).

With reference to the hypothesis of heat causing a diamond to break or explode when it is brought to the surface, the highest temperature to which it would be subjected above ground would be experienced on the depositing floors under the sun's rays, say about 60° C. (140° F.). The temperatures underground at the greatest depths yet reached are not so high as this, probably not touching 40° C. A large flow of water met with in the main rock tunnel at a depth of 1525 ft. in the Kimberley Mine had a temperature of about 30° C. (84° F.).

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* A few experiments have been made with the object of ascertaining whether a moderate heating (up to a temperature of 100° C. in water) will create strain in a diamond or vary a strain already there; but with no proof as yet that it can.

The theory that diamonds were broken by violent movements of the kimberlite does not explain the cause of the breakages among diamonds found in gravels, unless we may conclude that these diamonds were brought to the surface in outbursts of plutonic energy. Perhaps they were not so brought.

Again, a yellow diamond recently examined, having a very striated surface which prevented its interior from being properly seen, showed a crack running half the way round the outside of the stone. The polariscope indicated a great state of strain somewhere near the centre of the stone at a place where the crack seemed to extend inwards to. Now, if the expansion of contained gas had caused the stone to split, the gas must have escaped through the crack. Why, then, the continued strain? Again, where could the internal strain have come from if the stone had been broken by concussion in machinery or pipe? The De Beers Company has a diamond with a percussion figure like a clock-face under its surface, and in this case the shock which made the figure has set up no internal strain. We shall see in the following section how the strain and crack in the above yellow diamond have probably arisen.

12. SUGGESTED REASONS FOR BREAKING; MINERAL INCLUSIONS, ETC.

The suggestion now to be put forward, with all deference to better authorities, is that the circumstance of broken diamonds on a large scale is not alone due to:

(1) Either the spontaneous breaking up of those that are smoky or brown, or any other colour;
(2) Or to breaking in the process of mining and winning;
(3) Or to violent movements of the kimberlite in past time;
(4) Or to the expansion of contained gases within the diamonds whether by heating or relief of pressure outside,

though each or any of these actions may have been of some effect; but principally to the energy exerted by the mineral inclusions so often contained in diamonds. These inclusions are most frequently garnet, and there are, besides, zircon, ilmenite, iron pyrites, and (possibly) chrysolite.* There are also inclusions of what may loosely be called *splotches* of graphite (very numerous), oxide of iron, and chrome diopside (rare). Some of the black inclusions may be either ilmenite or hæmatite, or graphite, but they are so small that specific gravity tests (the only tests that are available without breaking the diamond) are not delicate enough to determine which. Diamonds possibly tinted by diopside have turned up now and then; but only one hitherto in our mines, containing a definite splotch of the material. But some years ago a beautiful specimen of a diamond was found in the Voerspoed Mine (O.F.S.), which contained a number of bright green splotches, doubtless diopside. This stone is now in the possession of G. F. Williams, and is probably peerless of its kind for beauty. A genuine crystal of chrome diopside has yet to be found in a Cape diamond; although it has been met with in bort.

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* Or enstatite: "A bright green variety occurs in large cleavable fragments in the diamond-bearing detritus of Colesberg Koppje in the Transvaal"!—H. Bauerman, Text book of Descriptive Mineralogy,' 1897. Some of this material is harder than window glass.

Bauer (p. 192) states that "until recently no diamond had ever been observed attached to another mineral in such a way as to suggest that the two grew side by side at the same time. The discovery, however, of a diamond crystal attached in this way to a garnet shows that such a growth does take place, though rarely." This assertion besides being bad science is bad history. The phenomenon is neither rare nor new. Evelyn relates in his diary how on Michaelmas Day, September 29, 1645, he visited the collection of the noble Venetian Signor Rugini where he saw "above all a diamond which had a very fair ruby (? garnet) growing in it."

In the majority of cases the garnet, or other inclusion, is not actually inside the diamond, but is set more or less deeply in a cleavage face. Also a very great number of cleavage fragments contain somewhere in their fractured surfaces small rounded holes or indentations such as could scarcely arise in breaking unless the holes or indentations had been there first, with something inside them. This latter circumstance indicates that diamonds containing inclusions have been more frequent in nature than we should infer from even the considerable number found with the inclusion present Some of these holes may possibly have contained gas or liquid.

In trying to interpret the facts we have to bear in mind that the thermal expansion of pretty well all crystals, saving those of the beryl family, at ordinary temperatures, is much greater than that of the diamond. Between 0° and 100° C., for example, the coefficients of cubical thermal expansion are for:

Zircon	0·2835
Garnet	0·2543
Quartz	0·3530
Diamond	0·0354

Whether these relative values would hold under plutonic conditions of heat and pressure is perhaps uncertain, though the coefficient of thermal expansion for diamond is said by Miers to increase rapidly at high temperatures and to diminish rapidly at low ones. For our present purposes very high temperatures need not concern us; nothing higher in fact than the comparatively low temperature at which garnets fuse, since there does not appear to be any evidence that the garnets of the Kimberley Mines have ever attained this temperature. "One character," says Church ('Precious Stones,' p. 64), "common to all garnets save Uwarowite is their fusibility before the blowpipe; they thus yield a vitreous mass which is of much lower density than the original garnet before fusion." This refers to experiments in air, of course, and things may be somewhat different under pressure deep down in the earth. In any event, the garnets of our mines have probably not been subjected to very high temperatures because none seem to have been found of the requisite low specific gravity. Kimberley garnets vary in specific gravity, it is true, but none tested in the De Beers office have been anything like so low as 3, the value for vitreous garnet. We shall, doubtless, be on the safe side in assuming that the thermal expansion of garnet, zircon, etc., under temperature conditions that are reasonably probable, is always greater than that of diamond, though not necessarily greater by a constant multiple.

Two alternatives are conceivable. First suppose a diamond to have crystallised about a foreign body, such as a garnet, and that at some subsequent time there was an increase of temperature in the surrounding magma. It is clear that a greater relative expansion of the inclusion would put the diamond into such a state of strain that, if the magma were not solid, the diamond might give way and break. That there has been such an elevation of temperature is rendered not improbable by the large number of diamonds showing signs of corrosion (? Luzi's figures), and by the coatings of graphite on others; possibly also by the phenomena of flaked diamonds. In the De Beers collection is one of these, a stone the greater part of which is in thin opaque grey laminæ, like an oyster-shell.* The state of this diamond was for a long time erroneously attributed to shattering by dynamite, but it is more likely to have been caused by overheating in the pipe during some past time. Many Premier diamonds, also, show incipient local flaking ("feathers") on their surfaces. Some of the diamonds belonging to the Emperor Francis I are said to have split into thin flakes when heated in a crucible. Elevation of temperature may also be indicated by the opaque white material, unaffected by hydrofluoric acid, occasionally found in local patches on diamond surfaces. Quite a large area of a certain lump of black bort from the Premier Mine was thus covered. A similar-looking stuff—perhaps the same—occurs, however, in some of the cavities in the cleavage faces of diamonds and round enclosed garnets, which makes it difficult to understand how it could be produced by heating; for the heat required should presumably have destroyed the diamond surface outside before it could reach the cavity.

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* The crystalline part of this diamond is a non-conductor of electricity, but the laminated part conducts as well as bort.

Another guess that might be made is that the diamond crystallised about the garnet at some pretty high temperature, and that the relative expansion of garnet as compared with diamond was less than it might have been at some later lower temperature. In this case it would be the cooling as plutonic activity died away that would set up the fracturing.

Whether we accept either alternative or neither, it is certain that diamonds do cleave freely across foreign crystal inclusions. Here is a case in point: A very fine diamond, weighing 42 carats and valued at over £600, was recently found in the Wesselton wash. It is a fair-shaped octahedron, as Cape octahedra go, and is much indented with the shallow triangular depressions characteristic of its mine. It contains the most lovely inclusions one can imagine—one apparently a small garnet, another a honey-coloured zircon, just deep enough in colour to show, *very* faintly, two colours in the dichroscope, of fair size. Through, and surrounding the position of, the supposed garnet is an extensive crack, while both above and below the zircon, and tangential to it, are similar cracks. These cracks are parallel to contiguous faces of the diamond, and neither reaches the surface of the latter.* The zircon with the two parallel cracks touching it exhibits an odd resemblance to an airplane in flight. Under the polariscope a state of great internal strain is manifested over a large area in the region of the zircon by a most magnificent coloration, while the zircon itself is equally splendid. Words indeed are insufficient to describe the chromatic beauty of the polariscopic view. Curiously, there appears to be no strain to speak of in the vicinity of the crack through the garnet, as though the strain which once must have existed there and caused the crack had been relieved.

Of course, one would expect more strain in general about a zircon inclusion than about a garnet one because of the somewhat greater coefficient of thermal expansion of the latter, especially along one of its crystal axes. This outstanding specimen illustrates very well the force of the two alternatives mooted above. For as internal strain still persists in spite of the present moderate temperature of the stone, it would appear that either the diamond must have crystallised at a surprisingly low temperature or at some high one at which its coefficient of thermal expansion must have been relatively greater, compared with that of the zircon, than it is now.

Arising out of the condition of the specimen in question an interesting point emerges:

Some broken diamonds, as we have said, show rounded holes in their cleavage faces, but others do not. Now we cannot conclude that those which do not show the holes were not broken by the expansion of a foreign mineral inclusion; for if the cracks bounding the zircon in our specimen were to spread outwards all round to the diamond faces, it looks as though, from their position, neither of the two outer fragments, of the three into which the diamond would break, would show signs of holes. Thus, even when a cleavage surface exhibits no imprint of a former mineral inclusion, it does not follow that the cleavage was not caused by an inclusion. It may be surmised, in passing, that the cracked yellow diamond spoken of in the last paragraph of Section 11 contained a mineral inclusion.*

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* In another, similar, case the cracks did reach the surface.

The remarks in the present section apply in the main to more or less transparent diamond. Opaque diamond, other than bort, often enough is flawed, has little cohesion, and can be easily broken.

13. Diamond Inclusions.

Diamonds enclosed in diamonds are not exactly uncommon. There are two very fine, nearly white, fair-shaped octahedra preserved in the De Beers office, each containing an inclusion. Both inclusions are practically of the same colour as their enclosures: one, a rounded octahedron, is certainly a diamond; the other is probably a diamond, but may be something else—say quartz as a remote possibility. These diamonds show very fine colour effects under the polariscope, but neither is much flawed internally. Where the strain comes from, though, when one diamond encloses another is an enigma.

Inclusions of diamond in diamond are not often symmetrical octahedra. One which was almost perfect in outline has been referred to in Section 4. A full description of this interesting object, which is still preserved, has been given by Williams (p. 506). The majority of such inclusions are irregular. A certain piece of Bultfontein cleavage, for example, which came from the wash already cracked nearly through, was found, when broken up, to contain a venerable-looking and ill-shapen flake of diamond, the cavity in which it had been being lined with a soapy-looking substance, possibly apophyllite. In this connection it is strange that the apophyllite, or whatever the subslance may be, prefers to stick to the enclosure and not to the inclusion. Pretty often in cases of this sort the portions of diamond separated by the crack are of different quality and colour.

Tiny cavities, or what look like cavities, in diamonds are not uncommon. They may contain gas. It is not the rule to find any large amount of mechanical strain in their vicinity.

14. Diamonds in the Matrix.

Bauer tells us (p. 192) that different portions of one and the same broken diamond are never found lying close together in the matrix. He should have said that he had not heard of such a case. As a matter of fact a shattered diamond, mixed up with garnet and olivine, was extracted from its kimberlite matrix in the De Beers sorting office a few years ago. Furthermore, on two or three occasions it has happened that a diamond has been pieced together from its fragments found in the same wash, proving either that it had been broken in the machinery, or that the same fragments had come from somewhere close together in the pipe. And no doubt other fragments could be so pieced together if the sorters had nothing better to do than look for them. For another thing the finds of broken diamonds in the matrix have not been over many, much too few indeed to formulate general conclusions upon. Of the hundred or so specimens of diamond in the matrix which have reached the sorting office, the majority have been whole diamonds. More specimens could have been procured, no doubt, had they been sought for, especially in the hard blue ground lumps mined from the deeper levels of the De Beers or the Kimberley Mines; but a diamond in the matrix takes some finding, and a searcher might have to turn over many tons of rock before setting eyes on a diamond. At any rate, twenty is a liberal estimate of the number of broken diamonds found in their matrices that have been available for investigation; and there is no earthly reason why in some of these twenty cases we might not have found corresponding fragments of the diamonds could we have found corresponding halves of the matrices. Speaking of matrices, a fine lump of kimberlite, in dimensions about five inches long by four thick, picked up some years ago, contained two well formed diamonds, one a large yellow, the other a small brown one.

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* But diamonds suffering strain, and with visible internal cracks, though apparently containing no inclusion, are sometimes met with.

15. YELLOW DIAMONDS.

A word must be said about yellow diamonds. From the representative assortments of Pool and Dutoitspan diamonds, given near the beginning of this paper, we get the following comparisons:

	Pool. Per cent.	Dutoitspan. Per cent.
All stones	19·24	24·96
All cleavages	38·98	41·71
Rejection chips, rubbish, and bort	41·77	33·21

Thus there are twice as many cleavages as stones in the Pool, and about one and three-quarter times as many cleavages as stones in the Dutoitspan. Of these, yellow diamonds alone (including off-colours) are:

	Pool. Per cent.	Dutoitspan. Per cent.
Yellow stones	7·68	8·66
Yellow cleavages	11·04	9·93

and leaving out brown and "fancy" (which are largely brown) diamonds, which are:

	Pool. Per cent.	Dutoitspan. Per cent.
Fancy stones	—	3·01
Brown cleavages	5·79	7·88

we have left, of faintly tinted diamonds, whether spotted or not:

	Pool. Per cent.	Dutoitspan. Per cent.
Stones other than brown or yellow	11·56	13·29
Cleavages other than brown or yellow	22·15	23·90

That is, the ratio of yellow cleavages to yellow stones is less than the corresponding ratios of brown or of colourless diamonds. It must have been on the basis of some such results as these that Bauer thought he had discovered that coloured diamonds resist fracture better than white ones. Pool information was probably all he had at his disposal at the time.

The significance of the above Pool and Dutoitspan statistics is to be gathered from the fact that foreign crystal inclusions in yellow diamonds are scarce. It is rare indeed for a yellow diamond to come in with a garnet or other mineral embedded in a broken face; and still more for such a mineral to be seen inside a whole stone. With regard to the latter contingency, however, it must be admitted that it would not always be easy to see an inclusion through the common sulcate faces of a yellow stone, though the former is evidence enough that foreign inclusions cannot be frequent. Again, South West African diamonds are often yellow, and the percentage of cleavages to stones is not great among them. An irregular yellow diamond, with grey corners, in my possession contains a garnet in a broken face. A piece of the garnet has been broken away exposing an excellent surface of attachment on the diamond. Spaces in the cavity between the diamond and the garnet are filled up here and there, as usual, with an opaque white substance.

The impression one gathers by way of inference from all these particulars, as well as from a scrutiny of the produce of the various mines round about Kimberley, is that nearly every yellow stone was formed rapidly in one piece out of a single bubble of liquid carbon (stained with iron oxide), or out of a bubble of some solvent containing carbon, thus occluding foreign solids; whereas the Wesselton or the Bultfontein octahedron was built up more slowly, step by step, and layer by layer, thus incorporating foreign solids in the diamond mass. Naturally, a small, loose, foreign, solid body in a cavity larger than itself, occupied by a carbon bubble, would lie at the bottom of the hole if its specific gravity were greater than that of the bubble, or at the top if its specific gravity were less, and in either case need not be imprisoned in the final diamond crystal, though it might stick to a natural face of it. In the case of a diamond crystal continuing to grow by accretion of matter from adjacent carbon bubbles, the foreign solid might be imprisoned in the crystal, but not otherwise. Now clearly there would be more chance of this accretion in magmas where the bubbles were smaller and more numerous—as must have been the case for certain in the Wesselton and Bultfontein Mines,—than in magmas where the bubbles were larger and much further apart, as at Dutoitspan. In other words, assuming that diamonds can grow if they get suitable opportunities; they got plenty of opportunities in Wesselton and Bultfontein, but not many in Dutoitspan. Thus, on this view, there is a relativity between

(α) The numerous accretionary structures;

(β) The frequent foreign inclusions;

(γ) The numerous and small diamonds, of such a mine as Wesselton, and;

(α′) The few accretionary structures;

(β′) The rare foreign inclusions;

(γ′) The fewer and larger diamonds, of such a mine as Dutoitspan. And this view is confirmed to my mind by such casual inspection as I have been able to make of diamonds won from mines situated outside the Kimberley district. In particular we may say that where diamonds are few or many in number, in any mine, there accretionary structures will be rare or numerous respectively. Wesselton diamonds are singularly accretionary.

How far apart from one another Kimberley diamonds *in situ* are may be illustrated by some examples. From May 16th to June 5th, 1917, eighteen working days, 129,640 loads, 2,074,240 cubic feet, of Dutoitspan blue ground were washed, yielding 20,957 carats of diamonds of all sizes, of which a first count gave 40,800 tiny diamonds averaging 78 to the carat (and only worth a penny a piece!), and 36,600 larger ones, of which one was of 126 carats and another of 174 carats; 77,400 diamonds in all, or one to every 27 cubic feet of broken blue ground, equivalent to one diamond to every 17 cubic feet of solid ground before mining. A similar count for Bultfontein showed 174,300 tiny diamonds and 207,900 larger ones, 382,200 in all, in 940,390 cubic feet of solid ground, or 1,504,624 cubic feet of broken ground, *i. e.* one diamond to every 2½ cubic feet solid, or to every 4 cubic feet loose. Corresponding Wesselton results are 210,000 tiny diamonds, and 232,000 larger ones, 442,000 in all, in 1,717,730 cubic feet of solid ground, or 2,748,368 cubic feet of broken ground, *i. e.* one diamond to every 4 feet solid or to every 6¼ feet loose.

Before passing to other matters, it is worth while to suggest that the prevalent rounded form of yellow diamonds is not due, as has been suggested, to attrition or abrasion—the sulcate surfaces of these is suggestive of anything but that—but to the temperature at which they were crystallised and the influence of the colouring matter they contain.* Some such reason may account for the Pool or the Dutoitspan macles. A remote analogue is the fact that it is the presence or absence of magnesia which has determined whether the red crystal of the Burma ruby mines was to be the regular spinel or the rhombohedral ruby—remote, because in this case the magnesia is an important constituent of the spinel. A closer analogy is the prevailing prismatic habit of the (red) ruby as compared with the pyramidal (blue) sapphire; also aquamarine and emerald crystalline in somewhat different habits. On the other hand, variations in composition do not much affect the habits of garnet and tourmaline. Speaking at large, it may be said that among Kimberley diamonds form depends to a great extent upon colour. Thus, octahedra tend to be colourless; yellow diamonds are mostly rounded; bright yellow macles are decidedly uncommon, even in mines where yellow diamonds abound; ordinary grey bort, when it is symmetrical, is generally in cubes and spheres.

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* "Rounded edges and other surface irregularities may, however, result from the corrosion of a crystal subsequent to its growth" (L. J. Spencer, Art. "Crystallography" in 'Ency. Brit.,' 11th ed., 1910). Surface abrasion is only shown to perfection on diamonds won from alluvial gravels.

16. DIAMOND ENCLOSURES.

Just as foreign crystal inclusions are found in diamonds, so diamonds are found embedded in foreign crystals. It is the garnet that is chiefly seen associated with the diamond in this way. All Kimberley garnets are rolled or broken pieces, scarcely ever, if at all, possessing natural crystal faces. Generally also, though not invariably, the embedded diamond shows signs of wear and tear, proving that it must have had a history before the garnet formed upon it. Since, then, garnets are found in diamonds and diamonds in garnets, it follows that both must have originated in the same era of geological time and have crystallised under similar conditions.

Crystal diamond and bort are also found related to each other in a similar way.

17. YIELD.

The following table, taken from the last Annual Report of the De Beers Company, is interesting. It shows the yield in carats per hundred loads of the Wesselton and Bultfontein blue:

Table showing the Yield of Diamonds for Wesselton and Bultfontein.

For the 12 months ending June 30th.	Wesselton. (Carats.)	Bultfontein. (Carats.)
1898	27	—
1899	30	—
1900	30	—
1901	30	—
1902	30	21
1903	30	24
1904	28	29
1905	28	41
1906	28	36

For the 12 months ending June 30th.	Wesselton. (Carats.)	Bultfontein. (Carats.)
1907	32	32
1908	27	32
1909	34	38
1910	32	37
1911	27	38
1912	29	41
1913	27	42
1914	28	38
1915	26	35
1916	26	40

If the diamond content of the pipes be assumed constant at all depths, we should expect that better methods of extraction with progress of time, to give better yields. Since there are no signs of a better yield at Wesselton, the conclusion ought to be that the ground there gets slightly poorer with depth. At Bultfontein there would seem to have been an improvement with depth. At the latter mine there is a rough sort of correlation, accidental or not, between the yield and the quality of the diamonds given by it which may be expressed thus: When the yield of carats per hundred loads increases, the percentage of inferior diamonds tends to decrease; in other words, the diamonds are of the best quality where they are packed closest together. When Nature had an abundance of material she used it well in the interests of the market! This is for any given mine; it does not apply comparing one mine with another. For instance, Bultfontein has a higher yield than Dutoitspan, but not such good diamonds. Bultfontein blue ground is somewhat patchy; Wesselton, though poorer, is more uniform.

The De Beers and Kimberley yields are published together as one Annual values are given in the following table:

Table showing the Yield of Pool Diamonds.

For the 12 months ending June 30th.	Carats.
1892	92
1893	105
1894	89
1895	85
1896	91
1897	92
1898	80
1899	71
1900	67
1901	76

For the 12 months ending June 30th.	Carats.
1902	76
1903	61
1904	54
1905	46
1906	41
1907	37
1908	37
1909	42
1910	38
1911	28
1912	31
1913	29

Prior to the amalgamation of the various small companies working the De Beers and Kimberley Mines, the yield was considerably over 100 carats per 100 loads. Not only that, but many of the smaller diamonds used to be thrown away in the rough and ready methods of winning, leaving great heaps of tailings and *débris* well worth washing again in later years. Thus it would seem that the greatest wealth of these two mines was concentrated in the upper levels. On the other hand, only the richer areas were worked to any great extent in the earlier years, the poorer areas being left to spoil the averages of later times.

The Dutoitspan yield for the four years 1911–14 averaged about 22 carats per 100 loads.

18. ANOMALOUS BEHAVIOUR OF DIAMONDS ON THE GREASE TABLES.

Diamond appears to have a curious affinity for lime. It was discovered some years ago that diamonds from the Wesselton yellow ground were not readily caught on the grease separators, while it was exceptional for a diamond from the blue ground to fail to be caught. Experiments showed that yellow ground diamonds cleaned in acid lost their non-adhesive property and behaved normally on the tables like blue ground diamonds, whereas blue ground diamonds immersed for a few days in a paste of soft magnesian limestone, or of yellow ground, or in water that had been shaken up with lime or with yellow ground and dried, would not stick to the grease. Evidently the diamonds had acquired a thin coating of lime, which, when wetted, lessened the surface tension between them and the grease, and so caused them to behave like the ordinary gravel of the heavy pulsator deposit. Yellow ground, by the way, contains a large admixture of lime, some specimens losing a good half of their weight after treatment with aqua regia.

It is curious that diamonds left in the blue ground on the depositing floors for a number of years stick to the grease-tables less readily than those which are fresher from the mine. Some Bultfontein diamonds recently washed have this peculiarity. It is not unlikely that they have acquired a fine coating of lime from the soft limestone of the depositing floors.

19. ELECTRICAL CONDUCTIVITY.

True bort, and especially stewartite, is a good conductor of electricity. The regularly crystallised diamond is not, as is sometimes asserted, always a bad conductor. It is a bad conductor if its quality and texture be good, but if it be not highly transparent its electrical conductivity may be nearly as high as that of bort. Wesselton black bort, for instance, which is regularly crystallised though mostly in fragments, has a conductivity intermediate between transparent diamond and true bort. Some semi-transparent diamonds, greens and browns, are almost as good conductors as Wesselton bort Further, the conductivity will pretty often have different values along different directions of the same stone. As a rule, the better the quality the lower the conductivity, one exception being that shot bort, though a worse conductor than ordinary grey bort, is a better than Wesselton black bort. We may arrange diamonds in order of conductivity, from the lowest to the highest, somewhat as follows:

Fine transparent diamond.
Inferior transparent diamond.
Semi-transparent or translucent diamond.
Wesselton black bort.
Shot bort.
Ordinary grey bort.
Framesite (Transvaal black bort).
Stewartite.

It would appear from this that impurities have as much to do with the electrical conductivity of diamonds as the habit has.

20. RELATIVE VALUES.

The relative average values of diamonds exceeding about ·08 carat each in weight, from each mine, are approximately:

Dutoitspan	100
De Beers	86
Kimberley	76
Wesselton	68
Bultfontein	51

ADDENDA.

1. *On the term "Macle"* (see § 1).

According to English and French dictionaries, the word is generally said to be French and to be derived from Latin *macula* = a spot. Now it is true that most macles of diamond are spotted; but so are many well-shaped octahedra. Spots, indeed, are not by any means characteristic of macles, nor the most prominent feature. What is characteristic and prominent in macles is their shape and structure, so well expressed by the Dutch name "naadsteen" (seamstone). There is another French macle, namely, the water chestnut (*Trapa natans*), and in this case the origin of the word has not been traced. Was d'Isle thinking of the latter when he named the former?

2. *A Variation in the Size of Wesselton Diamonds, with Depth of Working* (see § 2).

It is curious that superimposed upon the irregular fluctuations of average size taking place from year to year, there appears to have been a definite increase in the average size of large Wesselton diamonds, *i. e.* in those of ten carats or more each. Also it takes a smaller yield now to produce a large diamond than it used to; and the ratio of the weight of large diamonds to the total yield has increased. This is best shown in a summary, *e. g.*,

Years.	Average size of large diamonds.	One large diamond in	Ratio of total weight of large diamonds to total yield.
1898–1906 . .	15·6 carats	769 carats	2·0 per cent.
1907–1917 . .	15·8 "	731 "	2·2 "

3. *Cubes and Spheres* (see § 6).

Cubes of translucent and of opaque bort are fairly common in Bultfontein, and of semi-translucent bort in Wesselton. Cubes of transparent diamond also occur, though rarely. The edges of the cubes are always much rounded. The indentations of the surfaces of some cubes tend to a square outline, giving an impression that the mass is built up of a multitude of tiny cubes, whereas the indentations of the surfaces of octahedra are mostly equilateral triangles in plan. Many cubes, as well as octahedra, are pitted with rounded holes (*cf.* § 12). An existing small yellow cube of transparent diamond shows internal strain.

Spheres of translucent bort are called shot bort. Apparently the crystalline aggregates in these incline to a radial arrangement about a central nucleus which in most cases revealed by cleavage, if not all, consists of a discrete core of diamond or bort.